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NASA TECH BRIEF

Experimental Investigation of Megawatt DC Arc Heating of Nitrogen

Four types of arc heaters, each with the capability of providing arc power levels in excess of 1 megawatt in nitrogen, were tested over a range of power levels and nitrogen flow rates to determine their value as heaters for hypersonic tunnels.

A multiple chamber arc heater incorporating four magnetically spun direct current arcs was operated at enthalpy levels of 4000 to 6000 Btu per pound at a nominal pressure of 2.0 atmospheres and nozzle throat diameter of 0.75 inch. The efficiency of this arc heater ranged from approximately 45 percent at an arc power of 0.6 megawatt to approximately 30 percent at an arc power of 1.2 megawatts.

An arc heater incorporating a gas-vortex-arc-stabilizing mechanism was operated with various nozzles to measure its performance at various pressures for nitrogen flow rates in the range of 0.03 to 0.06 pound per second. This vortex stabilized arc provided a means of attaining a very high gas enthalpy at moderate pressures. The maximum enthalpy attained was 16,500 Btu per pound at a pressure of 1 atmosphere. The gas flow at the maximum enthalpy consisted of a mixture of nitrogen and oxygen in the same ratio as in air; the mixture was injected at a total rate of 0.032 pound per second. Higher pressure runs resulted in lower enthalpies.

A heater incorporating split-ring electrodes which employed both the self-induced magnetic field of the rings and an external magnetic field to rotate the arc was investigated. These split-ring electrodes proved capable of operating at 7000 amperes without burnout and flows of 0.44 pound per second without arc blowout. Arc powers were limited by the physical limitation of the arc gap length; a maximum arc power of 2.1 megawatts and a gas power of 0.87 megawatt were attained. This maximum power point resulted in an enthalpy of 1900 Btu per pound at a pressure of 11 atmospheres.

A ring-cylinder electrode configuration, which had a 1-inch arc gap, permitted higher powers than the split-ring configuration. The ring-cylinder electrodes carried 7400 amperes without burnout and with these high currents did not blow out until flows of approximately 0.4 pound per second were reached. Maximum powers attained were 3.0 megawatts in the arc and 1.2 megawatts in the gas. The corresponding enthalpy was 3400 Btu per pound at a pressure of 11 atmospheres.

Notes:

1. The data derived in this investigation should be useful in the design of high energy heaters for various industrial processes.
2. Inquiries concerning this investigation may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10508

Patent status:

No patent action is contemplated by NASA.

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Category 02